INFILTRATION TESTING OF HOMES IN THE HOUSTON GULF COAST AREA

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ABSTRACT

Air Changes per Hour (ACH) are determined by construction and weather conditions. In this test, it was found that the ACH is equal to .59 plus .07 for every year of age the home has. The higher ACH values for age are due to deterioration and construction techniques.

The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) has a methodology for determining ACH based on component leakage areas. The results found using this method are close to the results found in testing new home construction. Weatherization and retrofitting can decrease the ACH in an older home, however, a significant decrease would generally require significant retrofitting and expense.

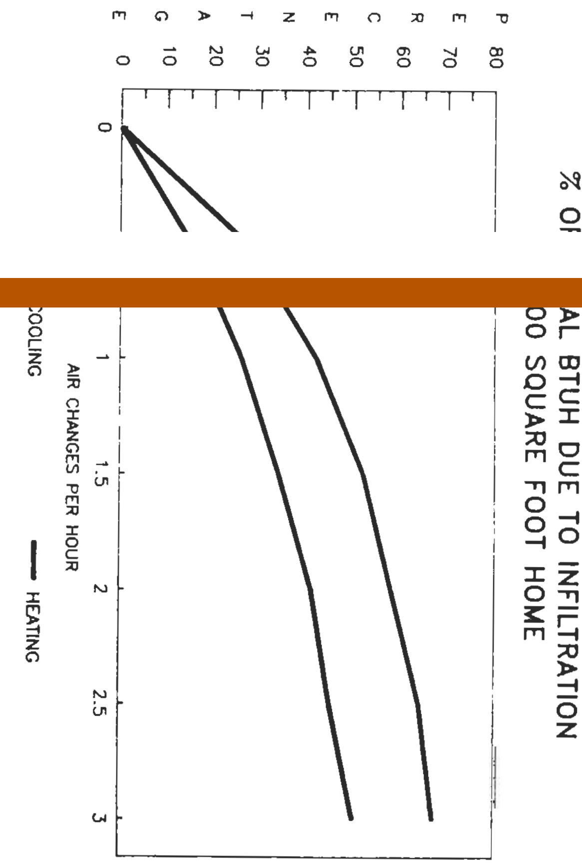
INTRODUCTION

Infiltration is defined as

interior and exterior. Heating and air conditioning loads are significantly effected by infiltration. In order to calculate these loads, the rate of infiltration is expressed in terms of air changes per hour (ACH); that is, the volume of air in a building that is displaced by outside air in a 1 hour period.

The Manual J Load Calculation Handbook (*1) specifies ACH values in a 2000 square foot home from .2 to 1.8. Load calculations based on Manual J procedures on a home of 1800 square feet in the Houston, Texas area show that when ACH is .7 (average new home), infiltration becomes a significant contributor to heating (20%) and air conditioning (34%) loads. Additionally, when the 1800 square foot home has an ACH of 1.5 (average existing home), infiltration is a major contributor to heating (34%) and air conditioning (52%) loads. (Figure 1) In this size home each air change per hour creates a cooling load of 13478 Btuh and a heating load of 10744 Btuh.

According to a paper written at Texas A&M University (*2) that addressed causes of discomfort in residential air conditioning, infiltration changes created greater discomfort levels than did changes in capacity or ambient temperature.



ASHRAE THEORETICAL
FIGURE 1

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INFILTRATION TESTING

There are several methods used to measure infiltration rates in a structure. Generally, these methods are divided into two types; the tracer gas methods and the fan pressurization method. In the tracer gas methods, a gas is released into the structure and is quantitatively measured over time to determine what rate it leaves the structure. These methods are quite accurate for determining ACH but are also difficult and expensive to perform. The fan pressurization method utilizes a fan sealed at an opening to withdraw air from the structure to a specified pressure. The pressurization of the air is then measured at various fan settings and this data is used to calculate an estimate of the ACH. This method is relatively simple to perform and it is a good indicator of the relative leakage due to infiltration. In this project, 22 homes were selected and tested for infiltration ratings using the fan pressurization method. In some homes, a typical weatherization was done and the fan box test was performed before and after the weatherization. This will show the value of some infiltration restricting measures in part and in whole.

The objectives of the testing are as follows:

1. To identify an appropriate value of ACH to use in the Houston area and; to identify items, construction practices, etc, that affect ACH and to measure the degree of this affect.
2. To utilize these findings to better serve all customers by identifying potential cost effective methods for reducing infiltration.

The ASHRAE Handbook of Fundamentals (*3) presents a method to estimate ACH by determining the effective leakage area (ELA) that a home has in square inches. This is found by adding the leakage area estimates listed in the tables for each component of the home that may allow infiltration. When this ELA is computed, it is plugged into a formula that relates wind speed and the house design to estimate the ACH. The initial analysis in this project utilize the ASHRAE methodology and the actual test results are then compared to the theoretical.

Air Change will depend upon the size and height of a structure, the tightness in terms of ELA, and the weather conditions (especially the wind speed). In utilizing the ASHRAE formula for ACH applied to the Houston area, it is found that 1 ACH is created by .016 square inches ELA per cubic foot of volume in a 1 story structure and .013 cubic inches ELA per cubic foot in a 2 story structure (Table 1). In other words, a 1 story home will have 1 ACH when 16 square inches ELA per 1000 cubic feet of volume are present and a 2 story home will tolerate only 13 square inches ELA per 1000 cubic feet of volume. In terms of comfort cost using local electric rates, each ACH is annually worth about $20 per 1000 cubic feet of volume. In an 1800 square foot home, 144 square inches of leakage area (1 square foot) costs $137.20 to heat and cool for a year. The effect of wind speed on ACH for various home sizes is shown on Figure 2.

TABLE 1

HOW MANY SQ IN LEAKAGE IS AN ACH?

A=	0.0156	1 STORY	0.0313
TD=	20		
B=	0.0119		0.0157
V=	8.1		

VOLUME	SQ. IN. ELA	1 STORY ACH
1000	16	1.00
2000	32	1.00
4000	64	1.00
8000	128	1.00
16000	256	1.00
24000	384	1.00
32000	512	1.00
40000	640	1.00

ACH= .016 ELA IN*2 / FT 3 VOLUME (1 STORY)

ACH= .013 ELA IN*2 / FT 3 VOLUME (2 STORY)

THE EFFECT OF SQUARE INCHES EFFECTIVE LEAKAGE AREA ON ACH AT VARIOUS VOLUMES.

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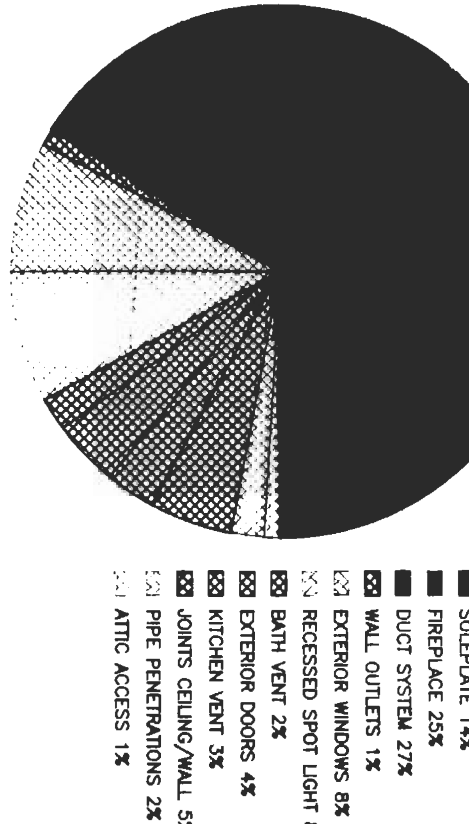

FIGURE 3 ASHRAE METHODOLOGY

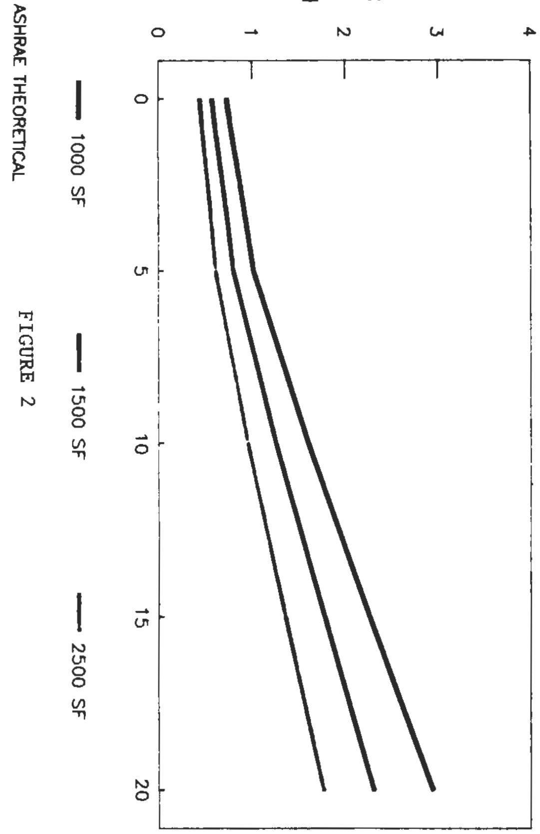

FIGURE 2

TABLE 2

FAN PRESSURIZATION TEST RESULTS AND RATING OF COMPONENT LEAKAGE AREAS

LOCATION	TEST % SMALL & LARGE LK	ASHRAE LEAKAGE AREA	IMPORTANCE RATING = 1 x 2
OUTLETS	100%	2	2.0
PLUMBING PENETRATIONS	59%	4	2.4
DRYER VENT	73%	4	2.9
WATER HTR CLOSET	79%	4	3.0
ATTIC ACCESS	100%	3	3.0
KIT VENT	53%	6	3.2
BATHROOM VENT	75%	6	4.5
FURNACE CLOSET	100%	5	5.0
DOORS	76%	9	6.8
BASEBOARD	24%	32	7.7
AIR RETURN	47%	22	10.3
WINDOWS	71%	18	12.8
RECESSED LIGHTS	85%	19	16.2
REGISTER GRILLS	53%	38	20.1
FIREPLACE	92%	54	49.7

The ASHRAE results are shown on Figure 3. In our study, we identified if an area had: no leaks, small leaks or large leaks. Wall outlets had a large or small leak 100% of the time. However, the relative severity of these leaks is not immediately apparent from our testing. For example, in a tight home the wall outlet may be the only noticeable leak area and so it would be indicated. However, this does not mean that it is the major leakage area in that structure. In fact, the ASHRAE methodology indicates that the wall outlet is the smallest leakage area. In Table 2, the various leakage components are shown with the test findings and the ASHRAE methodology. Also, an "Importance Rating" is listed to show the relative importance of an infiltration component in a typical home. For example, 92% of all fireplaces were found to have a leak and the ELA of a fireplace is 54 square inches. The importance rating of this is the multiple of the leakage area and the percentage occurrence which is the highest at 49.7. Therefore, a homeowner should be most concerned with leakage through a fireplace.

In this test, it was found that the ACH is equal to .59 + .07 for every year of age the home has. That is, a new home has an ACH of .59 and then there is an increase of .07 ACH per year age of the home based on all existing homes. Additionally, the ACH in older homes was theoretically adjusted to represent uniform construction practices of today. (Table 3) This gives ACH as a function of deterioration only (obsolescent construction practices factored out). The result is that ACH = .59 + .05/year. That is, a new home has an ACH of .59 and then there is an increase of .05 ACH per year age of the home based on existing homes that are similar in construction. (Figure 4)

TYPICAL WEATHERIZATION MEASURES

In part of our testing, we performed a weatherization on the home and ran the test before and after. The results are shown on Figure 5. Typical weatherization measures included the installation of gaskets around the outlets, caulking, and weatherstripping around doors. The before and after difference ranged from .017 up to .194 but was usually not more than .03. In the case where the difference was .194, a 12 inch x 12 inch hole was located and plugged in the oven vent area. The data was compared against the ASHRAE method and was found to be reasonably close (Table 4)

CONCLUSIONS

Air Changes per Hour (ACH) are determined by construction and weather conditions with construction the determining factor from a human standpoint.

In this test, it was found that the ACH is equal to .59 plus .07 ACH for every year of age of the home. The higher ACH values for age are due to deterioration and construction techniques. For example, 30 years ago most water heaters were inside the home. When air conditioning/heating was added to the home, these items created areas of leakage that are not found in new homes where the water heaters are typically in a non-conditioned area. The ACH due to age only was found to be .59 plus .05 ACH per year.

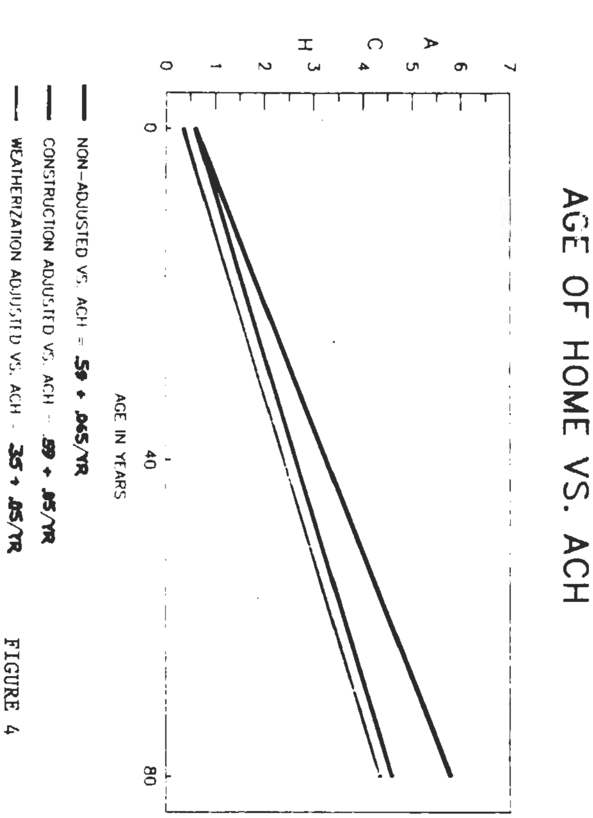

FIGURE 4

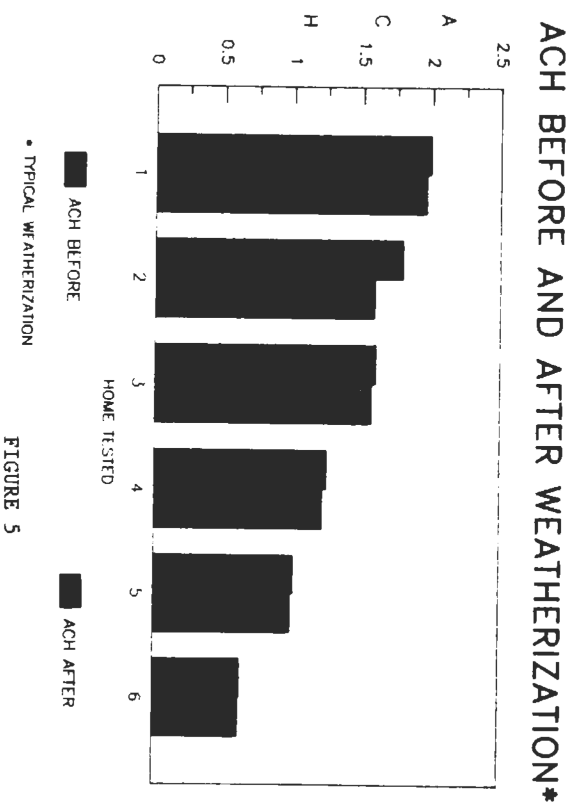

FIGURE 5

The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) has a methodology for determining ACH based on component leakage areas. The results found using this method are close to the results found in our testing in new home construction.

ASHRAE does not identify ACH due to deterioration which this test found to be about .05 per year. Weatherization and retrofitting can decrease the ACH in an older home, however, a significant decrease would generally require significant retrofitting.

The 4 most significant areas of air leakage in a typical home are fireplaces, air distribution systems, recessed lights, and windows.

REFERENCES

1. Manual J Load Calculation Handbook, Seventh Edition, 1986,Page 85.

2. Determination of the Transient Dehumidification Characteristics of High Efficiency Central Air Conditioners, Energy Systems Laboratory, Texas A&M Mechanical Engineering Department: Dennis O'Neal, July 1987.

3. ASHRAE Handbook of Fundamentals, 1985, Chapter 22.14.

TABLE 3
CONSTRUCTION ADJUSTMENTS MADE TO ACH

AGE OF HOME	CONSTRUCTION ADJUSTMENT TO ACH	CONSTRUCTION ADJUSTED ACH	CONSTRUCTION ADJUSTMENTS TO ACH TO ALL: JOINTS,SILL,KITCHEN FAN, DRYER VENT AND GAS WATER HEATER
50	1.031	3.199	AS ABOVE AND PIER FOUNDATION
80	0.869	5.161	AS ABOVE AND PIER FOUNDATION
35	0.719	1.069	AS ABOVE
12	0.389	1.211	AS ABOVE AND PIER FOUNDATION
20	0.258	1.732	AS ABOVE AND HOLE IN WALL
15	0.04	1.21	AS ABOVE

TABLE 4
ACTUAL ACH COMPARED TO THEORETICAL FOR KNOWN WEATHERSTRIPPING MEASURES

------MEASURED------			ASHRAE	ASHRAE-ACTUAL	WORK
ACH	ACH2	ACH DIFF	ACH DIFF	DIFF	DONE: INCLUDE EXT. CAULKING
1.99	1.96	0.03	0.029	0.001	7 GASKETS,1 DOOR, 1 FURNACE CLOSET
1.79	1.59	0.194	0.16	0.034	20 GASKETS,1 SF HOLE,2 DOORS, 1 HATCH, 1 DUCT
1.60	1.57	0.03	0.1	0.07	7 GASKETS,8 SI HOLES
1.25	1.22	0.03	0.019	0.011	25 GASKETS,1 DOOR
1.01	0.99	0.017	0.011	0.006	25 GASKETS
0.63	0.62	0.018	0.006	0.012	15 GASKETS